

Division of Materials Engineering and Testing Services

Electrical QA Inspection Pilot Program Report (Districts 1–4)



July 1, 1999 to June 30, 2000



Introduction

It has been the policy of the Department of Transportation to review, inspect, and test if needed, materials before their incorporation in to Permit and State construction projects. This material has been typically comprised of both State-furnished and Contractor-furnished electrical and non-electrical materials. This report will focus only on the quality assurance (QA) inspection needs for the contractor-furnished electrical materials.

Background

Prior to May of 1999, the inspection of contractor-furnished electrical materials had been primarily the responsibility of the Office of Structural Materials (SM) which is part of the Division of Materials Engineering and Testing Services (METS). The inspection duties were divided up among 3 branches that were each located in different parts of the State. The electrical inspection process and the level of involvement for each branch was as follows:

1. **QA and Source Inspection – Bay Area:** Most electrical materials were accepted on a Certificate of Compliance (COC). In cases where the Resident Engineer (RE) requested assistance with an electrical inspection, the branch primarily performed a visual inspection and subsequently tagged the material when it was compliant with the contract specifications. Any material that required extensive testing was shipped to the METS' Sacramento lab.
2. **QA and Source Inspection – Sacramento Area:** Most electrical materials were accepted on a COC. In cases where the RE requested assistance with an electrical inspection, the branch primarily performed a visual inspection and subsequently tagged the material when it was compliant with the contract specifications. Any material that required extensive testing was shipped to the METS' Sacramento lab.
3. **QA and Source Inspection – Los Angeles Area:** A total 5 PY's (1 senior electrical engineer and four technicians) were responsible for performing electrical QA inspections out of the METS' Los Angeles lab. Unfortunately the facility was not setup to perform in-depth bench testing so any material that required extensive testing was shipped to the METS' Sacramento lab. Therefore, the electrical inspectors primarily performed visual inspections and subsequently tagged the material when it was compliant with the contract specifications. Around 1990, with resources tight and a growing seismic program, decisions were made to start reclassifying the positions as they became vacant. By 1996, there was no personnel left to carry out the Southern California electrical inspection program. An expectation that district electrical construction inspectors would be able to fill the gap was not realized and as a result, the RE's ended up routinely accepting the contractor-furnished electrical materials on COC's.

In May of 1999, a memorandum went out from the Structural Materials Branch¹ stating that they would no longer perform electrical inspections and that the Testing and Technology Services Branch¹ (TTS) would now assume that responsibility. **(See Attachment A)**

As a result, TTS redirected 2 PY's and was given a 3rd PY to conduct a pilot study covering Districts 1 through 4. The rest of the districts were instructed to continue accepting electrical materials on Certificates of Compliance. This report summarizes the findings and recommendations of the pilot study.

Need and Support

The Federal Highway Administration's (FHWA) Federal-aid Policy Guide, Title 23 - The Code of Federal Regulations requires that each State Highway Agency develop and staff a quality assurance program that will assure that the materials and workmanship incorporated into each Federal-aid highway construction project are in conformity with the contract plans and specifications.

(See Attachment B)

Additionally, the following State guidelines and policies also require the implementation of QA program: **(See Attachment C for details):**

1. Caltrans' Quality Assurance Program Manual
2. Caltrans' Standard Specifications
3. Caltrans' Construction Manual
4. Caltrans' Source Inspection Manual

In the Spring of 1998, TTS surveyed the District and HQ construction, design, traffic operations and maintenance functions with regards for the need to re-establish a formal testing and inspection program. TTS received approximately 20 written affirmations of support. **(See Attachment D for the list of respondents)** There were no negative responses. Districts 8 and 11 Construction Division Chiefs (Brent Felker, at the time, and Jim Linthicum) confirmed their support in writing. Specifically, the construction managers were concerned that unqualified individuals were inspecting and releasing electrical materials, and that project delays were occurring as a result of these defective materials being discovered after installation. Furthermore, Maintenance and Traffic Operations managers felt that too many materials were failing prematurely and that it was more costly to deal with these problems after installation.

¹ On July 8, 1999, METS was elevated to Division status and all "Branches" became "Offices" and "Sections" became "Branches". These references allude the designations at the time of the memorandum.

Statewide Workload History

The large quantity of State construction projects that contain contractor-furnished electrical materials can not be overlooked. By looking at the data obtained from the HQ Office of Engineer's (OE) TEALE Database (**See Attachment E**), we can expect that 1 out of 3 projects will incorporate contractor-furnished electrical materials. More specifically, this amounts to approximately 216 Minor A and Major A projects per year that can be expected to fall under the METS' electrical QA inspection jurisdiction.

Additionally, if we make the conservative assumption that we will be involved in 2% of all Permits and Minor B contracts (16,000 issued annually), then we must add these 320 projects per year to the 216 projects per year mentioned earlier. This translates to a projected testing and inspection workload of 536 projects per year, or 45 projects per month statewide.

The Pilot Program

On July 1, 1999, a 1-year Pilot Electrical QA Inspection Program was deployed in Districts 1 through 4. The Electrical Testing Branch, which is part of TTS, was given the assignment.

A. Pre-deployment Set-up

1. A Filemaker database was developed and deployed to keep track of all of the contract and testing information. (Completed June, 1999)
2. An Electrical QA Inspection Manual was developed to be used by Caltrans personnel, manufacturers, vendors and contractors as a resource to understanding the electrical QA inspection and testing guidelines used by Caltrans. (Completed May, 1999)
3. Section 86-2.14A, Materials Testing, of the Standard Specifications was revised for the 1999 edition to avoid any ambiguity on where inspected materials were to be shipped to and tested. The length of time that the State had to complete such tests was also clarified. (Completed August, 1999, but will mainly affect contracts designed and awarded under the 1999 specifications)
4. Presentations were made at the annual District 4 RE Conference and the annual North Region (District 1-3) RE Conference. Presentations provided information on how the pilot program would affect the RE's. (Yearly)
5. Vendors, manufacturers, and contractors affected by the pilot program were visited and the program was discussed. (On-going)

6. QA testing and inspection activities were added to the METS WBS estimating spreadsheet so that resources would be made available on future work agreements between the Districts and METS. (Completed January, 1999)

B. Resources used for Pilot Program

Three fulltime PY's (a leadperson engineer and two technicians), a retired annuitant and a student were utilized for the pilot program. Additionally, an understanding was established in the Electrical Testing Branch that if the workload from the pilot program became too great that other personnel from the branch would help out in order to minimize overtime requirements.

C. The Inspection Process

The Office of Structural Materials remains the point of contact to receive all the CEM-3101's, "Notices of Materials to be Used" (formerly known as HC-30's). The Office of Structural Materials then reviews the form to see if any electrical materials are to be used on the job. If electrical materials are listed, then a copy of the CEM-3101 is forwarded to the Electrical Testing Branch, which then becomes responsible for these materials.

If the Electrical Testing Branch determines that the CEM-3101 does not provide sufficient detail, then form TL-608, "Notice of Materials to be Furnished" is sent to the contractor requesting that more detailed information (ie manufacturer, model number etc) be provided. Upon receiving this detailed information, the Electrical Testing Branch reviews the information and typically separates the electrical materials into 3 categories:

1. Materials requiring inspection
2. Materials to be accepted on a Certificate of Compliance.
3. Out-of-state materials or specialty materials such as pump motors, Highway Advisory Radios (HAR), Weigh-in-Motions (WIM), (etc) assigned back to the RE for inspection.

If an inspection is required, the Electrical Testing Branch will coordinate the sampling and testing of the materials in question. Typically the Contractor or Vendor is requested to set the material aside for inspection. The inspector may then either:

1. Visit the site where the material is located and choose samples, or
2. Request to have the entire shipment sent to METS for testing.

After the materials have been tested for compliance, an Electrical Test Report is generated. This test report will be used in lieu of tagging. **See Attachment F for a sample Electrical Test Report.** This test report states whether the material was found compliant or non-compliant with the State specifications. Any non-compliance issues will clearly be noted in the test report. Additionally, if an item is found to be non-

compliant, that item will need to be replaced or repaired before it is retested for contract compliance. **See Attachment G for a flow chart of the Electrical QA Inspection Process.**

It should be noted that while nothing is 100% foolproof, several safeguards were put in place to keep previously failed items from being reused on subsequent construction jobs:

1. The Electrical QA Inspection Program is project-based. Therefore in the event that a manufacturer should attempt to reuse previously rejected material on another State contract, there is a very good chance that the material will be caught on any subsequent project.
2. Serial numbers or distinct Caltrans identification numbers are noted on each Electrical Test Report and are captured in the database as well.
3. The material to be used on a construction job is set aside at the source until testing is completed.

Moreover, it should be noted that for the most part most manufacturers appear to be sincere in trying to provide the State with compliant materials.

One of the by-products of testing the materials is the development of a Reduced Testing List (RTL). This list will be solely distributed in-house for use by the Electrical Testing Branch's inspectors. The RTL is comprised of materials that have been repetitively tested and found to be compliant with the State specifications. The RTL will not only help minimize the repetitive testing of some of the most common reoccurring electrical materials but it will also free up time to devote to other areas of the program. These areas may include developing material specifications or working closer with manufacturers to improve problematic materials. The RTL will be continuously updated and tracked with the use of the database mentioned earlier.

D. Findings and Statistics

At the start of the District 1 through 4 pilot program, a projection was made with the aid of **Attachment E** that the pilot program would be involved in approximately 65 construction projects for FY 99/00. At the end of the pilot program, when the numbers were tallied, the pilot program was involved in 121 construction projects. See Figure 1 and 2 for the contract workload distribution for 99/00 fiscal year. This 86% increase over our projected workload for this FY may have been due to the highly fluctuating workloads presented by the permits and minor Bs. Another contributing factor may have been due to the fact that some construction projects may take several years to complete and as a result the contractor only buys the material on an as-needed basis. Hence the pilot program found itself receiving inspection requests from construction projects that were awarded in FY 98/99 and prior. This appears to be a variable that will produce deviations in the projected workloads for any given fiscal year.

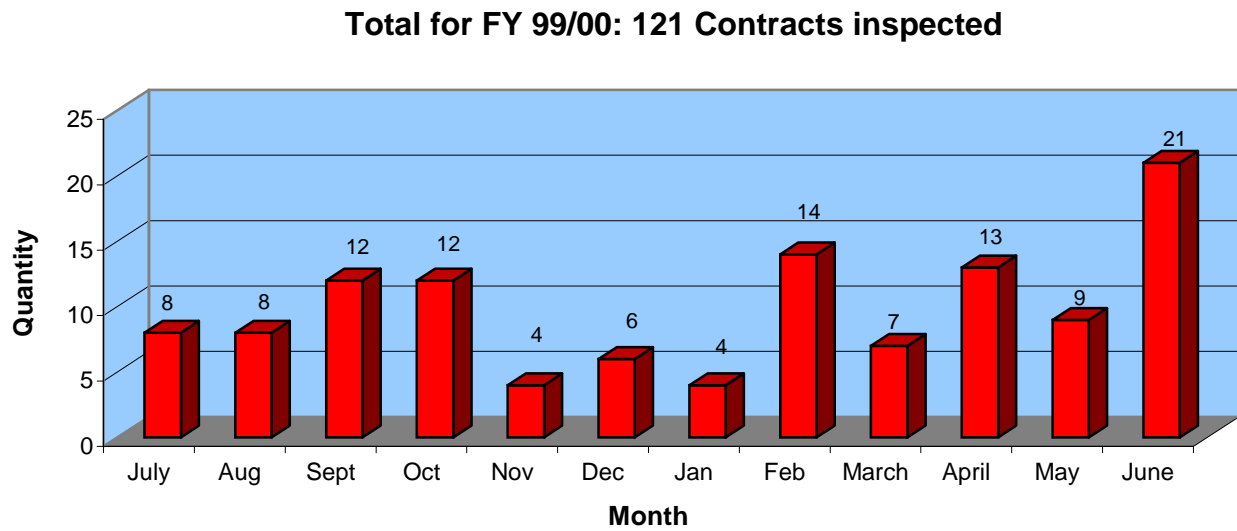


Figure 1. District 1- 4 Actual Contract Workload for FY 99/00

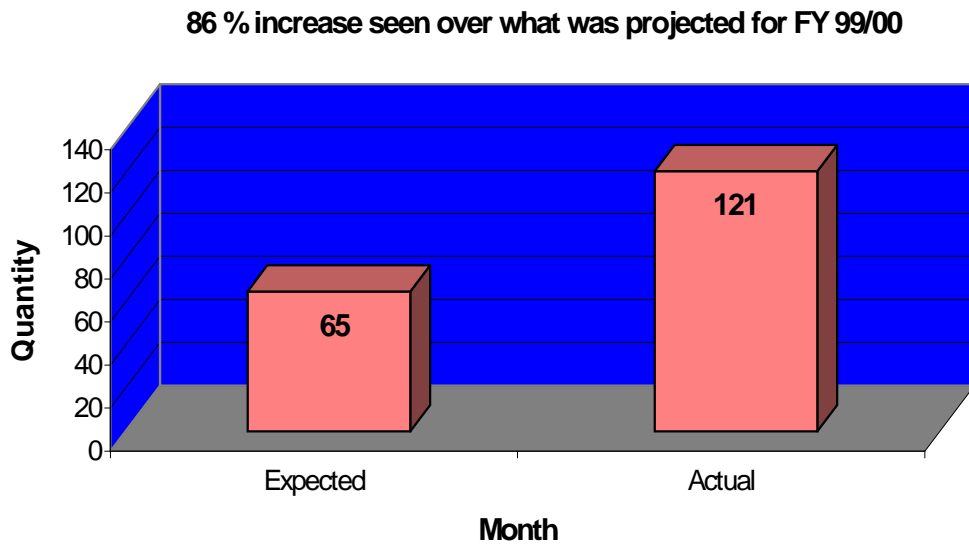


Figure 2. District 1– 4 Expected Contract Workload for FY 99/00

As shown in Figure 3, the Electrical QA Pilot Program oversaw the inspection of 3,896 electrical materials in FY 99/00. These materials consisted of everything from common items such as pullboxes to the more complex items such as Closed Circuit Television (CCTV) systems and service pedestals. Figure 3 shows that it was not until the last 6 months that there was some consistency in the monthly workload distribution. This may have been due to the fact that it took a while to disseminate the information to construction, the manufacturers, and the vendors that there was a formal electrical inspection program in place. This ramp up in workload can also be anticipated to occur if the inspection program is expanded in to the Central and Southern Caltrans regions.

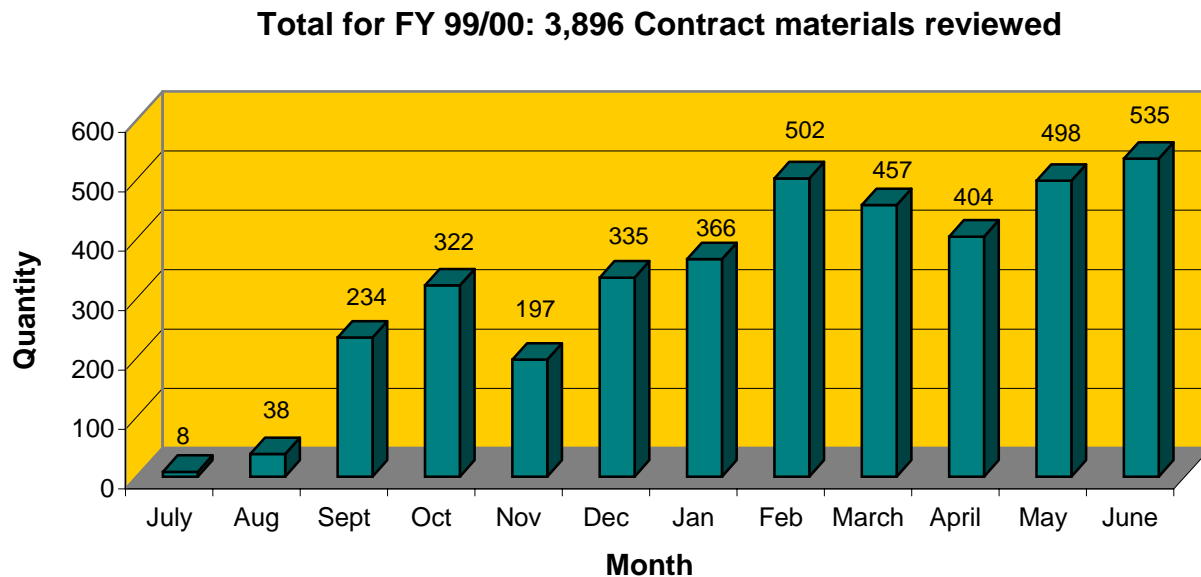


Figure 3. District 1- 4 Contract Item Workload for FY 99/00

Figure 4 shows the testing distribution for the 3,896 electrical materials that were reviewed. Of those materials, 2,267 (58%) of them were accepted on a COC and 1,629 (42%) were inspected. Furthermore, of the 1,629 materials that were inspected, we found that there was a 14% failure rate. The materials accepted on a COC were mostly comprised of materials that had been repeatedly tested and were moved to our RTL. It should be noted that these RTL materials are still subject to periodic compliance testing to ensure that they remain compliant.

The other interesting finding was that some unique items, such as service pedestals, will always require 100% inspection and can not be accepted on a certificate of compliance. In fact, the service pedestals were found to be 85% non-compliant on first inspections. This may have been due to the fact that each pedestal is unique and built to order per contract plans.

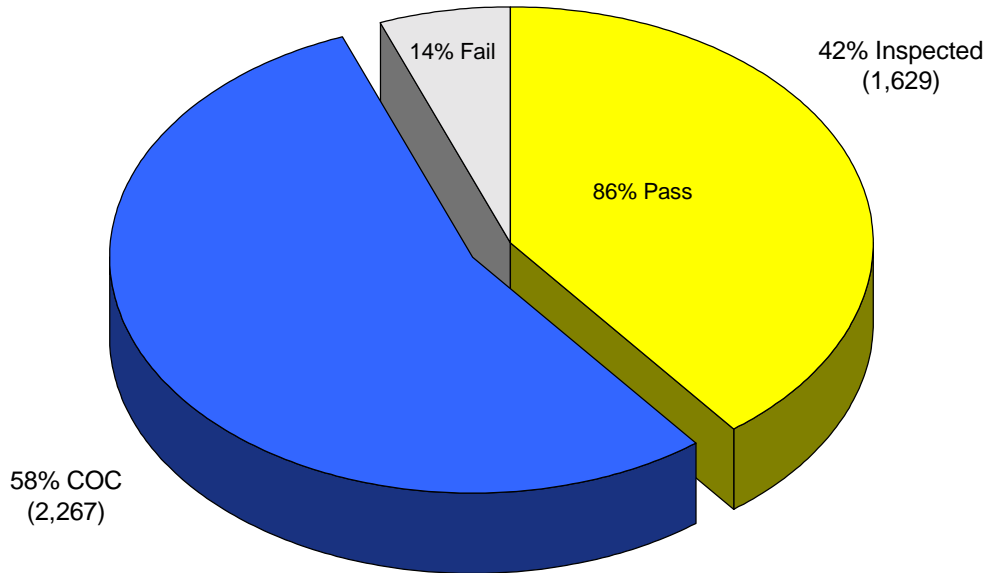


Figure 4. Testing Distribution for FY 99/00

Figure 5 shows that approximately 1.85 million dollars worth of electrical materials were inspected in FY 99/00. Some materials were relatively inexpensive while others were in the neighborhood of up to \$10,000 each.

Total for FY 99/00: \$1.85 million worth of electrical materials

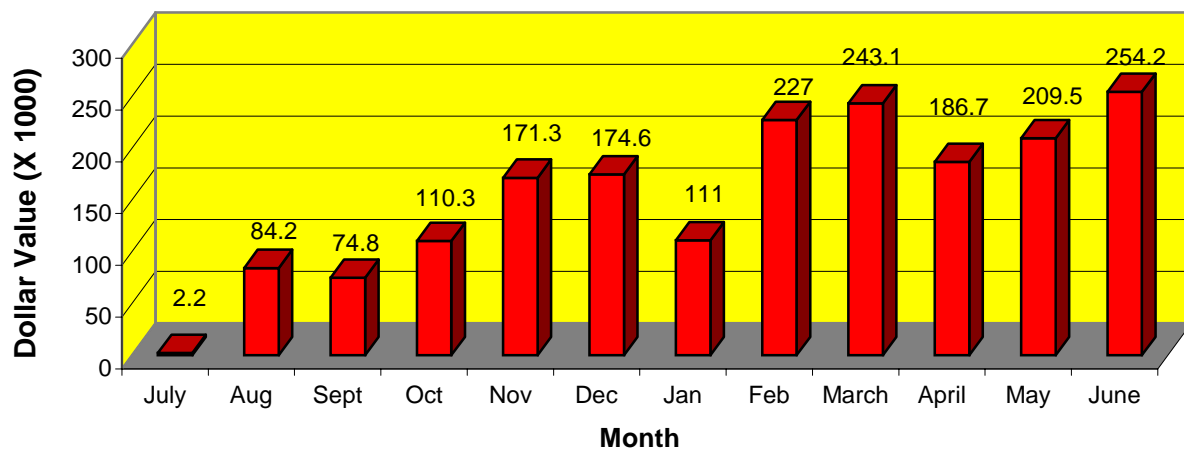


Figure 5. Dollar Value of Electrical Materials reviewed in FY 99/00 for Districts 1- 4

E. Cost / Benefit Analysis

The cost of performing this pilot program was approximately \$88,000. This translated to an initial inspection and testing cost of approximately 4.5 cents on the dollar (\$88,000 / \$1.85 Million). However, the cost of the pilot program was negligible when compared to the cost savings realized from:

1. not having to replace defective materials and,
2. not having on-site repair work performed by maintenance personnel.

The Cost/Benefit Analysis for the QA pilot program in FY 99/00 is shown below. The following statistical assumptions were used:

- The dollar value of the 238 (14% of 1,629) non-compliant materials was \$289,550.
- 1 of 3 of the non-compliant materials are defective and need replacing while the rest only need repair work .
- A minimum 4 hour call-out is performed by Maintenance personnel to repair each non-compliant material.
- 2 people are used on the call-out.
- Maintenance labor and equipment cost of \$55.00 per hour.

Based on the above:

Savings from not replacing defective material: (33% of \$289,550)	\$ 96,520
Savings from not having Maintenance personnel involved: (238 items x 4 hrs x 2 people x \$55/hr)	+ 104,720

FY 99/00 POTENTIAL SAVINGS	\$ 201,240
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Cost of operating Electrical QA Program in FY99/00	\$ 88,000
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RATE OF RETURN OF IMPLEMENTING ELECTRICAL QA PROGRAM	129%
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As illustrated, there was a substantial cost savings (129%) to the State by implementing the Electrical QA Pilot Program. Had we not performed the QA inspections, the State would have been adversely impacted by having to deal with \$289,550 worth of non-compliant material and would have potentially spent an additional \$104,720 in labor to remedy the problems. Furthermore, we anticipate that the 14% failure rate would have been much higher if the manufacturers had not been asked to correct their numerous non-compliant materials early in the pilot program.

Cost savings alone are not the only benefits of the QA program. By minimizing early failures of traffic control systems and lighting, and reducing worker exposure in the traffic zone, risks to both the traveling public and Caltrans maintenance forces will be reduced.

F. Workload Analysis

For the first few months, the pilot program took a reactive approach to getting involved with the construction projects. With this method, we used the receipt of the CEM-310 as the cue for our involvement in the construction project. However, after noticing that the projected workload did not materialize as expected, we decided to take a proactive approach. This approach required being part of the daily mail distribution loop for the Contract Award Summaries. This task was achieved in late September of 1999.

The Contract Award Summaries proved very useful. They allowed us to determine which contracts had electrical involvement and allowed us to ensure that we would be involved in EVERY construction project that contained contractor-furnished electrical materials. Hence, the Contract Award Summary became our cue for QA involvement. Unfortunately, 1/3 of the contractors did not comply with our requests for inspection. Therefore the amount of contract material processed by the Electrical Testing Branch was not a true reflection of how much electrical material was really installed in the FY99/00 construction projects.

Using the 2/3 workload assumption, we should be able to predict how many PY's will be needed to adequately cover Districts 1 through 4 when the program is fully implemented:

Calculation Assumptions:

- The last few months of the pilot program, when the proactive approach was fully implemented, provided the best representation of the dollar value (ie \$254K/ month) for an on-going program. See Figure 5.
- Only 2/3 of the contractors responded.
- 4.5 cents on the dollar is the cost to operate the program.
- 1 engineer PY = \$ 70K per year
- 1 Electrical Engineering Technician PY = \$58.5K per year
- 1 engineer PY and 2 technician PY's were used

The actual cost of operating the program when fully implemented in Districts 1 through 4:

\$254K /month x 12 months x 3/2 correction factor x 4.5 cents/dollar operation cost = \$ 206K or 3.3 PY's.

Note that only 2.6 PY's were actually expended on this 1-year pilot program. Hence, a fully implemented QA program in Districts 1 through 4 will require additional PY's.

G. Inspection Problems Encountered and Possible Solutions

The following is a list of some of the inspection problems and possible solutions that were encountered over the past fiscal year:

1. **Problem:** Some Resident Engineers are unaware of the electrical QA inspection program and the inspection process.

Solution: While we have found that most projects proceed smoother with the RE's support, there are still some RE's that are unaware of the benefits derived from having the material inspected. This should resolve itself when the inspection program becomes permanent and the benefits of using our services are shown at the annual RE meetings.

2. **Problem:** Some RE's were reluctant to support our inspection procedures since this was only a pilot program.

Solution: A memorandum from the METS's upper management should be sent to Construction making them aware that the Electrical QA Program is permanent.

3. **Problem:** CEM-3101's consistently do not arrive at METS in a timely manner. This short notice often results in rush testing of the materials.

Solution: Officially, the CEM-3101's are supposed to be filled out by the contractor, funneled through the RE and then sent on to METS. Since the CEM-3101 is required to begin the inspection process, it may be in METS' best interest to give a presentation at the annual RE conferences that stresses the benefits of submitting paperwork in a timely manner.

4. **Problem:** There is a reluctance to change from the tagging method to the Electrical Inspection Report method as a way of notifying the Resident Engineer on the status of the contract material.

Solution: Update the inspection process in the Construction Manual. Give presentations at the annual RE conferences and handout copies of the Electrical QA Inspection Manual which explains the new inspection procedures.

5. **Problem:** A small minority of contractors, vendors and manufacturers are resistant to the new inspection procedures or are not providing enough information on the material being provided.

Solution: Visit the resistant companies and explain to them that material testing is a contract requirement and that the whole inspection process will run smoother with their cooperation.

6. **Problem:** Up until now, the manufacturers have not had a contact to speak with on the interpretations of certain specifications and drawings. As a result, many manufacturers are producing materials that are marginally complying with the State Specifications. This may have been due to lack of specification enforcement over the years.

Solution: Visit and work with the manufacturers to help them resolve any questions that they may have with regards contract specifications.

7. **Problem:** Caltrans Standard Specifications and Plans are not clear in many instances.

Solution: Any inconsistencies or specification vagueness will be presented to the Statewide Electrical Specification Committee. METS has several members who are part of the committee.

8. **Problem:** Some manufacturers are reluctant to ship the contract materials to the lab due to shipping costs. Their argument has been that the Standard Specifications did not clearly call this out.

Solution: This will continue to be the case until we start seeing jobs being awarded under the 1999 Caltrans Standard Specifications (ie Section 86-2.14A). This will eventually become a non-issue.

9. **Problem:** No advance notice when Minor B's and Permits get awarded or go into construction phase. Since most Minor B's and Permits have short construction periods (30 days or less), we often do not have time to perform a thorough inspection.

Solution: Minor B's and Permits are normally handled at the District level without a HQ review. This process includes the bidding and awarding of the contract. Currently, we are in the process of trying to get in the loop of getting contract plans and specifications when the contract is awarded. In the meantime, we will try to accommodate everyone's workload as time permits.

10. **Problem:** Some failed electrical material impossible to track since they do not have serial numbers or lot numbers.

Solution: In time, we should be able to generate a specification that will require the manufacturers to place serial numbers on all their materials.

11. **Problem:** It is very costly to replace defective material once the construction job has been accepted and signed off by the RE. In most cases there is no warranty on the material once the material has changed ownership. Additionally the cost related to diagnosing the defective parts could be very costly.

Solution: The best solution is to continue with an inspection program that looks at the material prior to its incorporation in a construction project.

12. **Problem:** There needs to be more inspection training for specialty items such as WIM, HAR, or Microwave Vehicle Detectors Systems (MVDS).

Solution: Create a specification that will require the manufacturers to give training on the operation of their products.

13. **Problem:** Inadequate lab space available to test or store contract materials.

Solution: Add a portable trailer, sea-container or construct a new building.

Recommendation

The implementation of an Electrical QA Inspection Program is a valuable service that METS can provide to its District and HQ customers, a fact that has already been proven with the District 1-4 Electrical QA Inspection Pilot Program. This service will save the State money and will resolve risks to the traveling public and Caltrans Maintenance forces.

This program will also provide Caltrans personnel, contractors, manufacturers, and vendors with a standardized inspection process to follow when dealing with contractor-furnished electrical materials. This will lead to greater product uniformity and a reduction in non-compliance rates. In turn, this will reduce maintenance workloads and improve project deliveries.

The costs of operating the Electrical QA Inspection Program is minimal when compared to the savings that will be realized from reduced maintenance and defective material replacement costs. As with any new business venture, initial operating costs tend to be somewhat high in the beginning but tend to decrease with time as the bugs are worked out. In fact much streamlining has already been done since the pilot program's infancy.

Therefore, we are recommending that the Electrical QA Inspection Program be implemented statewide. This will require that the Electrical QA Inspection program be deployed in three phases. The first phase has already been deployed and also served as the pilot program for the North Portion of the state which covers Districts 1 through 4. This pilot program provided an opportunity to refine the approach and better define the workload. After review it was determined that the 3 PY's utilized for the pilot program was not sufficient to adequately cover this area.

The second phase will involve expanding the program in FY 00/01 into the Central Region of the state which covers Districts 5, 6, 9 and 10. It is estimated that this deployment can be initiated as early as September 2000. **All in all, a total of 6 PY's will be needed to cover both the Northern and Central Regions of the State.** All 6 PY's will be based out of Sacramento.

The third phase will involve expanding the program into the Southern Region of the state which covers Districts 7,8,11,and 12. This expansion should probably coincide with the opening of the new Southern Regional Lab (SRL) in Norco, California sometime in early FY 02/03. Lab space at the SRL and 5 PY's have been identified to cover this region. The lack of adequate testing facilities is the biggest hindrance in getting the southern districts online. It should be noted that even if an interim facility is used, it will most likely lack the specialized bench testing setups needed to ensure that the electrical materials meet the specifications. Any material requiring testing will need to be shipped to the METS' Sacramento lab. However, if deemed urgent, the expansion into this area could be accelerated.

In summary, as with any new program, the Pilot Electrical QA Program experienced many growing pains over the past fiscal year. We learned that perseverance and adaptation were our greatest allies in overcoming many of the hurdles presented to us. We also learned that some of the tools we developed, such as our database, allowed us to efficiently oversee the inspection of a large amount electrical material with a minimal staff. We also developed many great working relationships within Caltrans and outside of Caltrans.

Therefore given the opportunity, we feel confident that we have laid the foundation to provide a permanent statewide service that would not only benefit our internal customers such as Construction, Maintenance, and Traffic Operations but also our external customers like the contractors, manufacturers, vendors, and motoring public. The implementation of this program will ensure that California will continue to have one of the safest, best-managed, and seamless transportation systems in the world.